STEREOSCAN OBSERVATIONS ON THE POLLEN GENUS *CLASSOPOLLIS* PFLUG 1953

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ABSTRACT. The diagnosis of the pollen formgenus *Classopollis* Pflug 1953 is here emended after both a review of the literature and observation of numerous specimens recovered from Upper Triassic to Middle Cretaceous rocks in the Sahara, Israel, and France. Following a discussion of a proper definition of the species, twelve new species are described. Botanic affinity, taxonomic value, and stratigraphic occurence are also discussed.

NUMEROUS species have been validly assigned to the genus *Classopollis* both before and after the emendation by Pocock and Jansonius (1961). However, among isolated grains of apparently homogeneous assemblages from African or European Mesozoic rocks, it has proved impossible by light microscope to identify these species with certainty. Scanning electron microscope observations indicate four possible reasons: (*a*) the number of potential *Classopollis* species is greater than that of described species, (*b*) inexactness of the majority of specific diagnosis in the description of the exinal structure and sculpture, (c) the hierarchy of characters used to define species is variable depending on the individual author (often it is not indicated), (*d*) it seems that certain species have been defined on the basis of plurispecific assemblages, often unsuspected by the authors themselves. Because of its palaeobotanic and stratigraphic importance, a review of the genus has been undertaken using large assemblages extracted from the following formations: Upper Triassic (above Carnian) in the Tunisian and Algerian Sahara, Infraliassic and Lower Liassic in the Sahara and France (Saintonge, Massif Central), Jurassic and Lower Cretaceous in the Sahara, Israel, and France.

PREVIOUS LITERATURE

The genus *Classopollis* was instituted by Pflug (1953), although some species were previously assigned to other genera. Pocock and Jansonius (1961) presented an extensive review of past works and Boltenhagen (1968) completed this review by a critical survey of the literature.

Couper (1958, pp. 156–7, pl. 28, figs. 2–7) emended the genus *Classopollis* Pflug 1953, considering that Pflug's interpretation was inexact. After observations on pollen of *Pagiophyllum connivens* Kendall, he tried to show that the genus *Classopollis* is a morphographical taxonomic entity including all the species of the type met with in the above-mentioned fossil. Thus he suggested a very wide generic definition in which one must principally note an equatorial endexine thickness and a vague proximal trilete mark; he regarded *P. torosus* Reissinger as the type-species. Klaus (1960, pp. 165–7, pl. 36, figs. 57–60) emended the genus *Corollina* Maljavkina 1949 and included in particular Pflug and Couper's *Classopollis* species. In addition, Klaus suggested his species *Circulina meyeriana* as the type-species of the genus *Circulina* Maljavkina 1949. In his opinion this genus is recognizable by the following characters: a Y-form dehiscence, a distal polar area, a sub-equatorial ring which is not bordered with a thickening,

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occasionally parallel folds in the ring zone, and infrastructure without midrib, line, reticulum, or ring (striation ?).

Pocock and Jansonius (1961, pp. 443–4, pl. 1, figs 1–9) emended Pflug's genus, considering the attributions of Couper (1958) and Klaus (1960) as unfounded. They also emended *C. classoides* Pflug which they retained as type-species of the genus, and defined the genus with the following characters: (*a*) distally monoporate, (*b*) exoexine two-layered, (*c*) exoexine absent or much reduced over a circular area surrounding the distal pole and absent or reduced over a triangular area with its centre at the proximal pole, (*d*) intexine frequently bearing a reduced trilete scar, which has no germinal function, (*e*) exine always ornamented by striations, (*f*) the band, usually but not always, marking a zone of exinal thickening. Pettitt and Chaloner (1964) studied by electron microscope pollen grains extracted from a cone of *Cheirolepis muensteri* Schenk. They assigned these grains to the morphographical species *C. torosus* (without naming the author). They established that the exine of *Classopollis* is composite with a lamellate endonexine and a complicated ectonexine within which they distinguished an inner layer (ecn 2), a middle massive layer (ecn 1), and a tegillum. Burger (1966) suggested that the columellars (equivalent to ecn 2 of Pettitt and Chaloner) join in the equatorial belt and are reduced at the rimula. Reyre (1968*d*), using scanning electron microscope observations, established that at least in many cases trilete scars are functional, the outer layer of the exoexine is continuous with an invariable sculpture, the appearance of the grain is explained by variations of the intrastructure (similar to ecn 2 of Pettitt and Chaloner). In different parts of the grain it disappears, resulting in a subequatorial circular furrow, in a distal circular area and also in the proximal triangular area (when that exists); in these places, the outer part of exoexine (tegillum and possibly columellars of Pettitt and Chaloner) collapses and lines the lamellate endonexine which has the shape of a separate internal spheroidal envelope.

DEFINITION OF THE SPECIES

Numerous morphographic species have been described from various stratigraphic periods; they probably corresponded in most cases to different botanical species. However, the assignation of a dispersed *Classopollis* grain to a definite species is always difficult and often impossible.

Table 1 has been assembled from the diagnoses of five authors who have made detailed studies on *Classopollis*. It shows that, strictly, only the two extreme cases of size justify the recognition of two species on this one single character. If, however, one takes into account for each character, only the species in which it is clearly indicated, the number of possibilities for differentiation is one for all the characters except the sculpture where it is four. Table 1 underlines also the concommitant variations which affect the light visible characters. The statistical methods of symbolic dispersion diagrams (Pons 1964) can often record the different types or species an assemblage contains, but do not always permit the assignment of one or a few characters particular to each type.

For example, in the Jurassic and Lower Cretaceous rocks of the Tunisian Sahara, five *Classopollis* groups have been described: L_1, L_2, L_3, *scrabrate-verrucose* group, and *gemmulate* group (Medus and Reyre 1966). However, none can be assigned with any

TABLE 1. Comparative study of published species of the genus *Classopollis*.

Authors	*Species*	*1* *diam.* (μ)	*2* *Rimula*	*3* *trilete mark* (μ)	*4* *pore (diam.)* (μ)	*5* *intrastructure*	*6* *exine average*	*7* *thickness equatorial*	*8* *striations*	*9* *band width*	*10* *sculpture*
Couper	*torosus*	24–46	+	+	+	intrapunctate	0·75–1	3	4–7	5–8	scabrate
Pocock	*classoides*	18–24	+	3	12–15	intrapunctate	1–2	?	+	9	?
and	*belloyensis*	30–38	?	?	12	'caniculate'	2	6	8–10	12	?
Jansonius	*minor*	21–27	+	5–7	4	'caniculate'	1–3	?	10	6	?
	pflugii	26–33	+	+	?	'caniculate'	1·5	?	7	6	pits
Burger	*torosus*	23–29	+	+	5	intrapunctate	1–2	2·5–3	5–9	7–8	scabrate
	alexi	27–40	+	7–11	9–10	intrapunctate	1·5	1·5–2·5	8–10	10–11	perforate
	multistriatus	24–27	+	?	5	intrapunctate	1	1·5	10–14	8–9	psilate
	echinatus	24–26	+–	?	5	intrapunctate	1·5–2	?	3–5	4	echinate
	hammenii	23–29	–	5	7	intrapunctate	2–2·5	?	3–4	2·5–3	echinate
Groot	*major*	40–50	+–	?	10	?	?	?	+	5·8	granulate
	obidosensis	22–24	?	+	4–8	intrapunctate	?	?	+	4–7	?
Medus and	L_1	23–32	+	+	4–10	intrapunctate	0·5–1	?	7–11		psilate or scabrate
Reyre	L_2	26–39	+	+	4–9	intrapunctate	1–2	?	7–15		psilate
	L_3	18–23	+	+	2–5	massive or intrapunctate	1–2	?	5–11		psilate
	verrucose-scabrate	22–40	+	+	3–10	intrapunctate	1–2	?	7–12		verrucose-scabrate
Number of species recognizable by each single character		0	0	0	0 (1 above 12)	0 1 (massive)	0 1 (0·75)	0 1 (6)	0 1 (11–14)	0 1 (12)	0 4

certainty to definite species, because each has common points with several species depending on the characters under consideration. In addition, except for the gemmulate group, none has a constant individual character which allows a possibility of erecting a new species. L_3 is something like *C. classoides* of Pocock and Jansonius, but the pore diameter is smaller; it also resembles *C. torosus* sensu Burger but it is smaller, psilate, and sometimes massive. In the same way, L_1 resembles *C. multistriatus* Burger, but it is often larger, scabrate, and finer; its pseudopore is larger and the belt can have less striations. Only the *gemmulate* and *scabrate-verrucose* types are theoretically separated on sculpture; the first is easily distinguished but for the second this delicate and variable observation of sculpture cannot be made reliably with a light microscope.

Hierarchical order of use of characters. Two authors have put forward a hierarchical order. Pocock and Jansonius indicate successively the characters (as numbered in Table 1): 6, 2, 7, 8 and 9, 5 or 10 and 1. Their interpretation is not very clear on whether the ornamentation mentioned refers to the sculpture or the intrastructure although it would seem to be the latter because the authors have not mentioned the sculpture of their species. For Burger the order of characters is as follows: 10 and 5 (which can be different on the distal and proximal hemispheres of the grain), 2, 7, 8, and 6. Neither authors have indicated the reasons for their choice. However, the choice of hierarchical order is important, (*a*) to obtain a natural classification of *Classopollis* species (which will be attempted below), and (*b*) because it will be determinative in defining the different species. This fundamental study can only be undertaken on a homogeneous assemblage containing only one species. In fact it is difficult to predict, and experience shows that formations containing only one species are rare. Examples are:

1. Sample from bore-hole Lamarque 1, Aquitaine (Esso France: X = 358, 7; Y = 314, 4), depth 1742 m., Rhetian age (Dupin 1965), contains a *Classopollis* assemblage. Two extreme types are easily distinguishable by light microscope observation of the intrastructure. The first, type A (Pl. 55, figs. 1, 5) is light, almost translucent, with a massive intrastructure. The second, type C (Pl. 54, figs. 9, 11) is darker, with a pseudoreticulate intrastructure which is poorly defined in the area of the equatorial thickening. Between these extreme types, the intrastructure can be finely or poorly pseudoreticulate in the type B (Pl. 54, fig. 10 and Pl. 55, fig. 8).
2. Sample of argillaceous sandstone from bore-hole S_6P_6, Massif Central (B.R.G.M.: X = 566.500; Y = 179.075; Z = 190.90), depth 47·40 m., Hettangian (B.R.G.M. dating), contains a *Classopollis* assemblage of type C only (Pl. 55, figs. 11, 12).

Light microscope observation. Table 2 has been made up by selecting ten grains of each of the three types. It shows for these types whose general appearance and sculpture are perfectly homogeneous, the following points (each character is numbered in Table 2):

1. Size (diameter) is not fixed, but the variation is peculiar to the species
$$\left(\frac{\text{diameter of the smallest}}{\text{diameter of the largest}} \text{ varies from } \tfrac{1}{2} \text{ to } \tfrac{5}{6}\right).$$
2. When there is a circular furrow, it exists in all the grains.
3. Length of laesurae of trilete scar varies as much as 1:4.

TABLE 2. Character variations in the forms A, B, C (see p. 306). Measured characters: 1, size (diameter); 2, circular furrow width; 3, length of laesurae; 4, pseudopore diameter; 6, average exine thickness; 7, equatorial exine thickness; 10, type of stereoscan-visible sculpture.

Forms	1	2	3	4	6	7	10
A	30	1	8	8	—	3	echinulate
	28	—	5	8	—	2·5	micro-echinulate
	30	2·5	2·5	10	1·5	2·5	echinulate
	30	1	3	7·5	—	2·5	,,
	27	1	6	5	2	3	,,
	26	1	7·5	5	—	2·5	,,
	31	2·5	—	10	2	2·5	,,
	27	1	—	8	1·5	2·5	micro-echinulate
	25	1	2·5	4	—	2·5	echinulate
	25	1·5	5	—	1·5	2·5	micro-echinulate
B	27	—	6	7·5	2·5	2·5	grumous-verrucose
	27	1·5	—	6	2·5	1·5	echinulate
	27	1	2·5	—	2·5	—	,,
	25	1	5	7·5	—	2·5	,,
	31	1	6	5	2·5	1·5	,,
	23	1	3	—	2·5	—	,,
	26	1·5	5	—	2	1·5	grumous-verrucose
	23	1·5	5	7·5	2	2·5	echinulate
	30	1·5	8	8	2	2·5	micro-echinulate
	26	1·5	6	6	2	2·5	echinulate
C (sample 1)	24	1	5	6	1·5	—	echinulate
	28	1	—	—	1·5	2·5	,,
	32	1	—	—	1·5	2·5	grumous-verrucose
	34	+	12	10	—	—	,,
	28	+	3	—	1·5	—	echinulate
	28	1	6	5	—	2·5	,,
	26	1	—	8	1·5	2·5	,,
	18	1	4	—	1·5	—	,,
	24	1	—	8	1·5	2·5	grumous-verrucose
	21	1	—	5	—	2·5	echinulate
	28	1	7	—	1·5	—	micro-echinulate
C (sample 2)	30	1	6	5	1·5	2·5	grumous-verrucose
	28	1	—	—	1·5	—	,,
	20	1	—	—	1·5	—	,,
	32	1	8	10	1·5	2·5	,,
	32	1	10	8	1·5	2·5	,,
	28	1	—	—	—	—	,,
	30	1	7	8	1·5	2·5	,,
	24	1	—	—	—	—	,,
	28	1	5	6	1·5	2·5	,,
	26	1	5	6	1·5	2·5	,,

4. Pseudopore diameter varies as much as 2:5.

6, 7. Exinal thickness remains constant at comparable points and especially when there is an equatorial thickening.

Scanning electron microscope observations. Technical conditions for observations of exinal sculpture by the scanning electron microscope has already been set out in detail (Reyre 1968*d*). Results of the observations are as follows:

(*a*) In the case of the sample 2 (optically very homogenous intrastructure) the sculpture of the tegillum is identical in all the grains, grumous-verrucose (Pl. 55, figs. 13, 14).

(*b*) In the sample 1 three types of sculpture are observed. The optical type A can be micro-echinulate (Pl. 55, figs. 3, 7) or echinulate; the optical type B can be micro-echinulate or echinulate (Pl. 55, fig. 10) and rarely verrucose; the optical type C can be rarely micro-echinulate, generally echinulate (Pl. 54, fig. 13) or grumous-verrucose (cf. Pl. 55, fig. 14).

(*c*) Interpretation: the only light microscope visible characters (1–7 in Table 2) cannot establish how many species there are in the sample 1 or how they are distinguishable. Scan observations confirm that there is one species in the sample 2 and establish that there are at least three species in the sample 1. In sample 1 one species is common with the sample 2 (optical type C, grumous-verrucose) and two (optical types A and B, micro-echinulate or echinulate) correspond probably to two closely related botanical species, but one fossil pollen species is made because of the occurrence in the same sample. It thus appears on one hand that light microscope observation alone is generally insufficient to define the ultimate morphographical species, and on the other hand that intrastructure of one species can have a certain variability, generally limited. It also appears that each precise type of sculpture has the properties of one botanical species or a group of closely related species; that suggestion comes from the results established on actual gymnospermous pollen (Reyre 1968*d*) and on higher plants such as the closely related species of the genus *Aristida* L. (Bourreil and Reyre 1968) between which slight variations of outer sculpture can be observed and are peculiar to each species. It comes also from the observation of several homogeneous assemblages of *Classopollis* the sculpture of which is identical for all the grains (as the assemblage C, sample 2).

Inference. In the genus *Classopollis*, the outer sculpture of the grains is at the same time the most consistent and the most distinguishable character of a species; it is the ultimate specific character necessary for diagnosing the species; the consequence is that a diagnosis would not be valid, either from a morphological point of view or from a botanical point of view if it does not show the exine outer sculpture observed by electron microscope.

LIMITS OF THE GENUS

In his generic diagnosis, Couper (1958) extended the genus to all the pollen with an equatorial thickening and a vague trilete scar. The definition of Pocock and Jansonius (1961) was different and narrower, requiring the presence of striations, of a distal pore, and of a proximal triangular area either with or without a trilete aperture. The form-genus *Classopollis* can thus be conventionally limited to the simultaneous presence of the above-mentioned characters. However, this convention could result in a separation of closely related palaeobotanic entities and so we must consider that the absence of each of these characters on one of these pollens excludes it from the genus *Classopollis* when this absence results in either the absence or a notable modification of the other characters.

Striations. Considering the pollen groups A, B, and C, in which no striations are observed on the first two and a vague line arrangement on the third, it can be seen that they all have a pseudopore, a subequatorial circular furrow, an equatorial thickening, and an outer sculpture very similar to that of *Classopollis* with clearly defined and continuous striations (compare Pl. 55, figs. 8, 10 and Pl. 57, figs. 1, 5). Further, in the succession of types B, A, and C, it is easy to distinguish a progressive passage from a massive intrastructure to pseudostriations. It would be unhelpful to limit the genus *Classopollis* by the actual presence of striations, as Pocock and Jansonius have done.

Equatorial thickening. The pollen shown on Plate 55, figs. 5–7, has no equatorial thickening. It is, however, in all other characters, similar to the grains of the group B, in which it has been included. Pocock and Jansonius (1961), Groot and Groot (1962), and Burger (1965), recorded no equatorial thickening in several of their species with striations.

On account of these two factors I consider that the formgenus *Circulina* (Maljavkina) Klaus 1960 is an exceptional case within the genus *Classopollis*, corresponding to the coincidence of the limiting cases of the two characters, equatorial thickening and ornamentation of the intrastructure.

Trilete scar. Table 2 shows clearly that a homogeneous assemblage can have a variable trilete scar (in particular length of the laesurae). Many assemblages have only a trifid or sinuous fold (Pl. 55, fig. 4) so that it is sometimes impossible, especially with a light microscope, to see a vestigial mark. But all the other characters are similar.

Pseudopore. All *Classopollis* have a more or less distinct pseudopore which is visible in polar view or with a scanning electron microscope. In certain species, however, it is less distinct, especially when the exine is thin. I have so far found only one form with striations but without a pseudopore (Pl. 54, figs. 8, 9) but neither does it have a trilete scar or a circular furrow, and this justifies its inclusion in the genus *Aporina* Naoumova 1937 (in Boltenhagen 1968). The European Jurassic species of the formgenus *Exesipollenites* Balme have a similar pseudopore, but no trilete scar and no circular furrow and they cannot be assigned to the genus *Classopollis*. Also, some species show an outer sculpture similar to that of recent Cupressales (Pl. 59, fig. 5).

THE TYPE SPECIES

I consider the generic name *Classopollis* is valid because the genera *Corollina* Maljavkina 1949 and *Circulina* Maljavkina 1949 were defined too vaguely. Like Pocock and Jansonius (1961) I consider that because of the impossibility of proving the exact similarity of *C. classoides* Pflug with another previously published species, the name of the type-species is *classoides*; but Pflug's diagnosis is inexact.

Of the grains selected for the diagnosis of the *classoides* species, it must be pointed out that the sample studied by Pflug could, in fact, include several species. Thus, even if Pflug's diagnosis is exact, it is impossible to recognize the species he wished to describe since there is no precise indication of the outer sculpture. From comparison of the relevant figures it appears that the species *C. classoides* (Pflug) Pocock and Jansonius 1961 does not correspond to the species represented by Pflug (1953). For reference these authors figure (Pocock and Jansonius 1961, pl. 1) a tetrad (figs. 1, 2) from Pflug's residue but different from the Pflug's *classoides* species by distinctive striations, circular furrow invisible and different intrastructure. They assign to the same species a distinctly intrapunctate grain without distinct striations (fig. 4) and a massive form without any striations (figs. 6, 7). It seems, therefore, that Pocock and Jansonius have also described a plurispecific assemblage; there is also no precise indication of sculpture. In fact the *Classopollis* type-species has never been fully described. Re-description of the type species *classoides* from Pflug's original residue would be difficult; after chemical or washing operations on this residue in glycerine, how could a grain be chosen? The new species, *C. kieseri* (Pl. 54, figs. 9–14) which resembles Pflug's *classoides* is erected in this paper from new material; but, in practice, for illustrating the genus *Classopollis* it would be preferable to refer to another species showing all the characters proper to this formgenus, striations in particular.

SYSTEMATIC SECTION

Diagnoses and descriptions of the species here described include in the same order all the characters mentioned in Table 1. The high-power Scan micrographs are very important because they show the general disposition of sculptural elements (simple, mixed, double), the similarity or the plurality of shapes and sizes of elements, the shape of these, their length, breadth, and abundance (number of elements on a surface unit). All these characters are mentioned in the same order in the descriptions. The detailed explanation of the method used for describing the exinal sculpture is indicated in a previous paper (Reyre 1968*d*), but see also the text-fig. 2. Light and electron photographs are not always of the same grain; it is difficult to take an immersion photograph of a grain which must be recovered from the liquid before being observed by the scanning electron microscope. However, they always represent grains of the same optical assemblage (which is electronically observed on numerous grains). Holotypes or paratypes of the species here described are preserved at the Geological Laboratory of the National Museum of Natural History, Paris.

Genus APORINA Naumova 1937

Remarks. This genus is separate morphographically, but the corresponding palaeobotanical taxa are closely related to the taxa which produced *Classopolliss* and may be species of the same genus.

Aporina sp.

Plate 54, figs. 1, 2

EXPLANATION OF PLATE 54

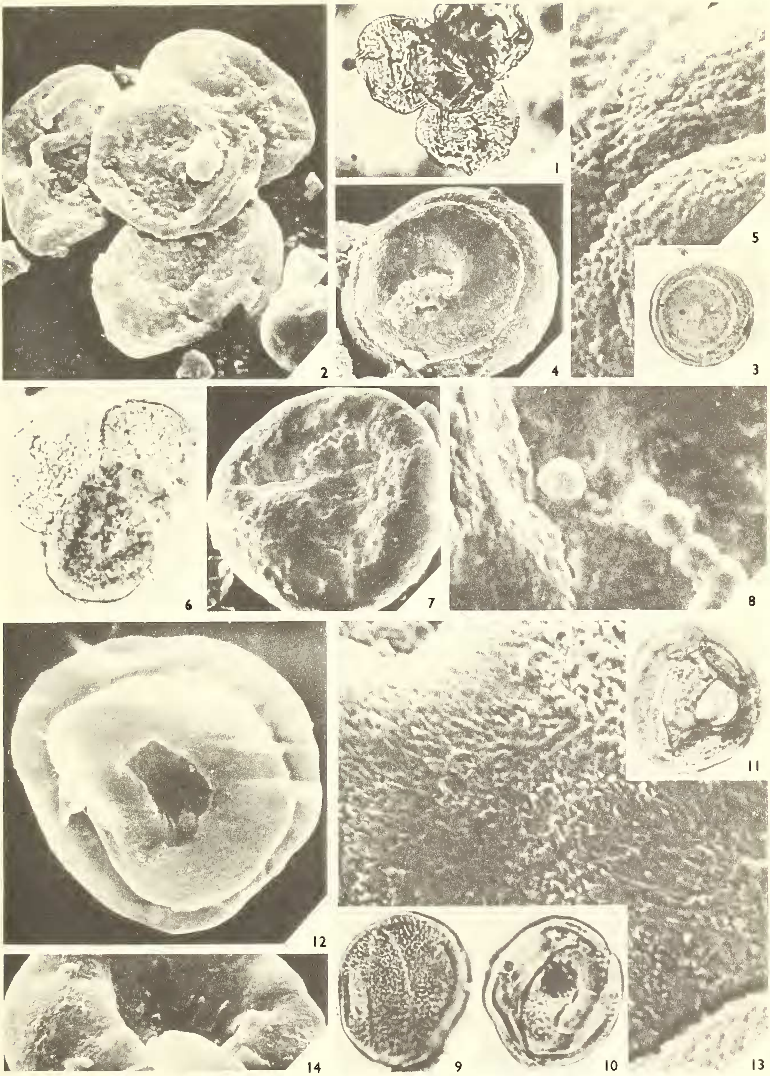
Light microscope figures approximately ×1000; Stereoscan figures approximately ×2000 and 10 000.

Figs. 1, 2. *Aporina* sp. 1, L.M. tetrad view showing striations. 2, S.E.M. view on which no pseudopore is observed.

Figs. 3–5. *Classopollis simplex* sp. nov. 3, L.M. holotype, showing massive to micro-alveolate intrastructure. 4, 5, S.E.M., showing the nipples of the outer sculpture.

Figs. 6–8. *Classopollis quezeli* sp. nov. 6, L.M. tetrad holotype, showing striations. 7, 8, S.E.M. holotype showing the outer double sculpture rough with bowls.

Figs. 9–14. *Classopollis kieseri* sp. nov. 11, L.M. paratype, showing pseudovermiculate to pseudoreticulate intrastructure, trilete scar, subequatorial circular furrow, pseudopore and exinal thickness. 9, 10, L.M. paratypes, figures very similar to that of Pflug. 12–14, S.E.M. holotype, showing outer sculpture of exine, hairy with spines; S.E.M. paratype, showing the trilete scar.

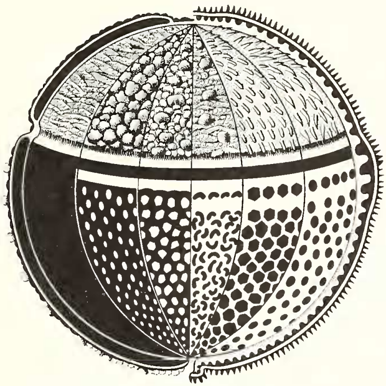


REYRE, Triassic and Jurassic *Classopollis*

Description. No subequatorial furrow; no trilete scar; no pseudopore; intrastructure massive; average exinal thickness 0·5 μ; equatorial thickening 1 μ; 4–6 striations 6 μ; band width 4–5 μ. Sculpture simple, isomorphous, nearly isodiametric, slightly rough and nearly psilate.

Size range. 17–22 μ (28 specimens).

Stratigraphic position. Upper Triassic (post-Carnian) of the Sahara; bore-hole ON_1 (X = 31° 46′ 07″, Y = 6° 25′ 36″, Z = 140 m.), depth 2660 m.



TEXT-FIG. 1. Outer sculpture (designed on the distal hemisphere above); from left to right: rugose, verrucose, mixed, double, echinulate or hairy with sticks, echinulate or hairy with needles or spines. Intrastructure (designed on the proximal hemisphere—below): from left to right: massive, alveolate, reticulate, vermiculate, pseudoreticulate, punctate.

Genus CLASSOPOLLIS Pflug 1953 emend.

Text-fig. 1

Emended diagnosis. More or less spherical prepollens with, both more or less marked, a distal circular pseudopore and a proximal trilete scar; this latter is clearly visible, but sometimes it is vestigial or a sinuous (or trifid) crease takes its place; often it is open and it appears to have had a germinal function (unlike the pseudopore). Exine is two-layered with distinct endoexine and exoexine. Fndoexine is shaped into an internal spheroidal separate envelope. Exoexine composition is variable on different parts of the grain; it is composed of an inner complicated layer which constitutes the light microscope visible intrastructure and a tegillum. The tegillum is shaped into a separated outer envelope present all over the grain and covered with an outer sculpture uniformly distributed on the whole surface of the grain. Intrastructure is massive, alveolate, punctate, vermiculate or pseudovermiculate, reticulate or pseudoreticulate but can be absent, reduced, thickened, and differently organized on different parts of the grain;

it is absent or reduced at the distal pole (pseudopore) or only along the circular line surrounding it, absent along a subequatorial line (circular furrow) and sometimes at the proximal pole (triangular area), generally thickened in the equatorial zone of the grain under the circular furrow (equatorial band) where the intrastructure elements are organized into more or less continuous striations.

Remarks. Two reasons justify this emendation: (*a*) in respect of the generic diagnosis of Pocock and Jansonius the present emended diagnosis takes into account the actual knowledge on the structure of *Classopollis* grains; this is important for the understanding of the species and allows recognition and definition of the different species or records by consideration of precise characters. (*b*) the limits of the formgenus *Classopollis* are different from those indicated in the diagnosis of Pocock and Jansonius.

Classopollis simplex sp. nov.

Plate 54, figs. 3–5

Diagnosis. Subequatorial circular furrow present; trilete scar present, length of laesurae 3–6 μ; pseudopore diameter 2–4 μ ; intrastructure massive to micro-alveolate; average exinal thickness 1 μ; no equatorial thickening; no striations. Sculpture simple-mixed, isomorphous, heterodiametric, with nipples; nipple height 0·1–0·2 μ, breadth 0·2–0·3 μ, abundance 12 per μ^2. Many elements overlap a little the bases of the nipples; they are also less rounded nipples, 4 μ high.

Size range. 18–24 μ (40 specimens).

Holotype. Plate 54, figs. 3–5; size 20 μ.

Stratigraphic position. Upper Triassic (post-Carnian) of the Sahara; bore-hole ON_1 (X = 31° 46′ 07″, Y = 6° 25′ 36″, Z = 140 m.), depth 2660 m.

Classopollis quezeli sp. nov.

Plate 54, figs. 12–14

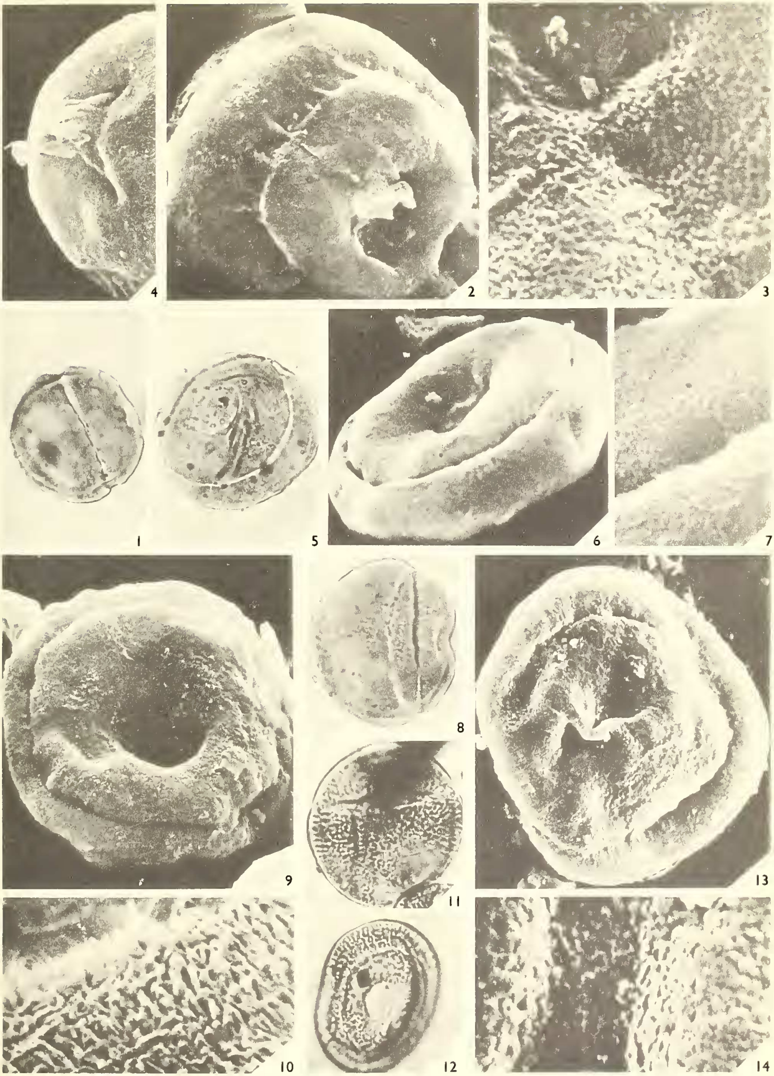
Diagnosis. Subequatorial circular furrow present; trilete scar vestigial; pseudopore diameter 4 μ; intrastructure massive (to micro-alveolate); average exinal thickness less than 1 μ (bowls not included); equatorial thickening 1 μ; 4–5 striations; band width 5 μ. Sculpture double, heteromorphous, heterodiametric, rough with bowls; processes height 0·1–0·2 μ; breadth 0·1–0·2 μ; bowls 0·9–1 μ.

EXPLANATION OF PLATE 55

Light microscope figures approximately ×1000; Stereoscan figures approximately ×2000 and 10 000.

Figs. 1–10. *Classopollis kieseri* sp. nov. 1, L.M. paratype, showing massive intrastructure and equatorial thickening. 2, 3, S.E.M. view of same grain showing small spines of outer sculpture. 4, S.E.M. view of same grain showing outer layer of exoexine lacerated at the proximal pole. 5, L.M. view of a paratype without equatorial thickening. 6, 7, S.E.M. view of same grain, sculpture micro-echinulate. 8, L.M. holotype, showing micropseudoreticulate intrastructure and sinuous circular furrow. 9, 10, S.E.M. holotype, showing sculpture echinulate, hairy with needles.

Figs. 11–14. *Classopollis chateaunovi* sp. nov. 11, L.M. paratype, showing vague pseudostriations. 12, L.M. holotype, showing pseudoreticulate intrastructure and pore. 13, 14, S.E.M. holotype, showing grumous-verrucose sculpture.



REYRE, Jurassic *Classopollis*

Size range. 18–24 μ (36 specimens).

Holotype. Plate 54, figs. 12–14; size 23 μ.

Stratigraphic position. Upper Triassic (post-Carnian) of the Sahara; bore-hole ON_1 (X = 31° 46′ 07″, Y = 6° 25′ 36″, Z = 140 m.), depth 2660 m.

Remarks. Processes are rounded so that the surface seems nearly mammilated.

Classopollis kieseri sp. nov.

Plate 54, figs. 9–13; Plate 55, figs. 1–10

Diagnosis. Subequatorial circular furrow present, narrow (1 μ) or wide (to 3 μ) by distortion and often sinuous; functional trilete scar present, length of laesurae 2·5–10 μ; pseudopore diameter 4–10 μ; intrastructure massive, pseudoreticulate or finely so; average thickness 1·5 μ; equatorial thickening 1·5–2·5 μ; no striations, to vaguely defined pseudostriations; band width 8–10 μ. Sculpture simple, isomorphous, isodiametric, micro-echinulate to echinulate (hairy with little needles); varying from grain to grain, needle height 0·1–0·5 μ, breadth 0·1–0·2 μ, abundance 9 per μ^2 (large needles) to 80 per μ^2 (small needles).

Size range. 21–(28)–34 μ (100 specimens).

Holotype. Plate 55, figs. 8–10; size 31 μ.

Stratigraphic position. Hettangian, bore-hole Lamarque I, Aquitaine, (X = 358, 7; Y = 314, 4), depth 1742 m.

Remarks. By scan observation of the sculpture it seems that there are three closely related species, in which the spines or needles are constant on any one grain but may be very small (micro-echinulate, Pl. 55, fig. 7), medium (Pl. 55, fig. 3) or larger (echinulate, Pl. 55, fig. 10); but these characters do not each correspond to one precise intrastructure type. For this reason and because of their simultaneous occurrence in the same sample one *Classopollis* species is made.

C. kieseri resembles *C. classoides* Pflug 1953 in many characters visible on the illustrations of this species. In Pflug 1953, plate 16, figs. 29, 30 show a pollen finely pseudoreticulate, with a sinuous circular furrow, a pseudopore, a trilete scar not visible but suspected, an exine thickness of 2 μ without striations.

Classopollis chateaunovi sp. nov.

Plate 55, figs. 11–14

Diagnosis. Subequatorial circular furrow present; trilete scar present, length of laesurae 5–12 μ; pseudopore diameter 5–10 μ; intrastructure pseudoreticulate; average exinal thickness 1·5 μ; equatorial thickening 2·5 μ; only vague pseudostriations; band width 8 μ. Sculpture simple, isomorphous, isodiametric, grumous-verrucose; breadth of grumes 0·2–0·3 μ.

Size range. 20–32 μ (100 specimens).

Holotype. Plate 55, figs. 12–14; size 31 μ.

Stratigraphic position. Hettangian, Massif Central, bore-hole B.R.G.M. S_6P_6 (X = 566.500, Y = 179.075, Z = 190, 91), depth 47·40 m.

Classopollis bussoni sp. nov.

Plate 56, figs, 1–4

Diagnosis. Subequatorial circular furrow present; trilete scar present, length of laesurae 3–10 μ; pseudopore diameter 4–10 μ; intrastructure finely punctate; average exinal thickness 0·5–1 μ; equatorial thickening 1 μ; 7–11 striations; band width 7 μ. Sculpture simple, isomorphous, isodiametric, rugose-verrucose; height of warts 0·2 μ, breadth 0·5–0·8 μ.

Size range. 23–32 μ (100 specimens).

Holotype. Plate 3, figs. 1–3; size 28 μ.

Stratigraphic range. Middle and Late Jurassic and Lower Cretaceous of the Sahara. Holotypes from bore-hole SB 1 (Tunisia, X = 8 g. 21′ 87″ E, Y = 34 g. 91′ 16″ μ, Z = 282 m.), depth 1210 m., Callovian.

Remarks. This species is included in the type L_1 (Medus and Reyre 1966), see Table 1.

Classopollis rarus sp. nov.

Plate 56, figs. 5–7

Diagnosis. Subequatorial circular furrow present, with a prominent swelling; trilete scar vestigial; pseudopore intrastructure reduced at the distal pole, but no well-shaped hollow is observed with electron microscope; intrastructure punctate to pseudoreticulate; average exinal thickness 1 μ; equatorial thickening 2 μ; 7–9 striations; band width 7 μ. Sculpture simple-pargeted, isomorphous, lightly heterodiametric, hairy with short sticks processes with well-rounded tips; height of processes 0·3–1 μ, breadth 0·2–0·5 μ, abundance 15 per μ^2. The pargeted appearance is explained by crowding of processes with the higher projecting above the shorter.

Size range. 23–34 μ (32 specimens).

Holotype. Plate 55, figs. 5–7; size 32 μ.

Stratigraphic position. Lower Portland of Charente, France; bore-hole Vignolles S2 (X = 390.6, Y = 29.3, Z = 15·50 m.), depth 14·80 m.

Classopollis aquitanus sp. nov.

Plate 57, figs. 1–5

Diagnosis. Subequatorial circular furrow present but difficult to distinguish; trilete scar present; pseudopore diameter 5–9 μ; intrastructure clearly reticulate (lumina 1–1·5 μ); average exinal thickness 1 μ; equatorial thickening 1·5–2 μ; 9–10 striations; band width 10 μ. Sculpture simple, isomorphous, heterodiametric, echinulate (hairy with

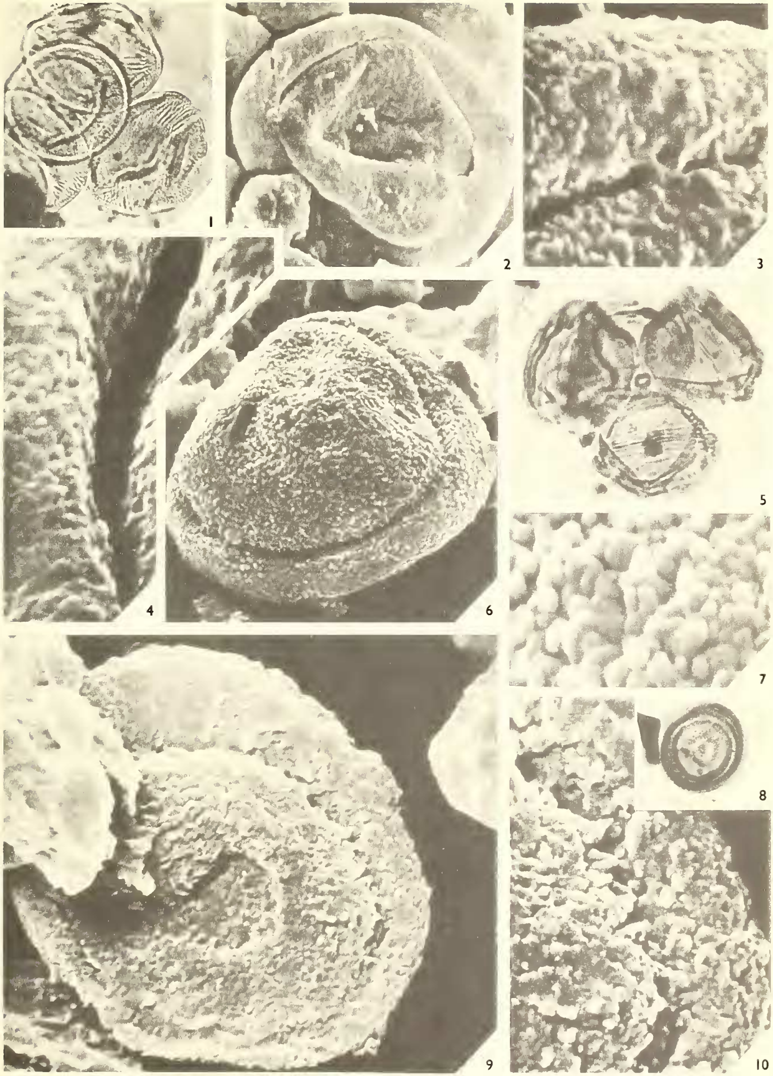
EXPLANATION OF PLATE 56

Light microscope figures approximately ×1000; Stereoscan figures approximately ×2000 and 10 000.

Figs. 1–4. *Classopollis bussoni* sp. nov. 1, L.M. holotype, view of finely punctate intrastructure and striations. 2, 3, S.E.M. holotype, showing rugose-verrucose outer sculpture with warts. 4, S.E.M. paratype.

Figs. 5–7. *Classopollis rarus* sp. nov. 5, L.M. holotype, showing punctate to pseudoreticulate intrastructure and striations. 6, 7, S.E.M. holotype, showing rounded short sticks of the outer sculpture.

Figs. 8–10. *Classopollis caratinii* sp. nov. 8, L.M. holotype, showing loosely punctate intrastructure, pseudopore, and trilete scar. 9, 10, S.E.M. views showing strongly rough sculpture.



REYRE, Jurassic and Cretaceous *Classopollis*

spines); height of spines 0·3–0·9 μ, breadth of base 0·1–0·4 μ, abundance 9 per μ^2. Some very short spines among the others.

Size range. 28–36 μ (100 specimens).

Holotype. Plate 57, figs. 1, 4, 5; size 31 μ.

Stratigraphic position. Lower Portland of Charente, France; bore-hole Vignolles S_2 (X = 390.6, Y = 89.3, Z = 15·50 m.), depth 28·80 m.

Classopollis caratinii sp. nov.

Plate 56, figs. 8–10

Diagnosis. Subequatorial circular furrow distinct; trilete scar present, length of laesurae 2·5 μ; pseudopore diameter 4 μ; intrastructure loosely punctate; average exinal thickness 1 μ; equatorial thickening 1·5 μ; 3–4 weak pseudostriations. Sculpture simple, heteromorphous, heterodiametric, strongly rough; height of processes 0·1–0·7 μ, breadth 0·1–1 μ; the shapes of the heteromorphous processes appear to be wrinkles, nipples, warts, blisters, or spines, although no shape is clear.

Size range. 16–20 μ (28 specimens).

Holotype. Plate 57, figs. 8–10; size: 18 μ.

Stratigraphic position. Lower Portland of Charente, France; bore-hole Vignolles S_4 (X = 390.6, Y = 89.3), depth 21·65 m.

Classopollis martinottii sp. nov.

Plate 57, figs. 6–11

Diagnosis. Subequatorial circular furrow present but often difficult to distinguish; trilete scar present, or trace; the outline of the pseudopore is not clearly marked and the intrastructure is only reduced at the distal pole which is often folded in Stereoscan observation; intrastructure finely punctate; average exinal thickness 1 μ; equatorial thickening 1·5 μ; 4–7 striations more or less discontinuous (lining of intra points); band width 5 μ. Sculpture simple, isomorphous, isodiametric echinulate (hairy with spines of which the ends are not sharp but rounded); height of spines 0·4–0·5 μ, breadth of base 0·2–0·3 μ, abundance 14–16 per μ^2.

Size range. 28–33 μ (70 specimens).

Holotypes. Plate 57, figs. 9–11; size 30 μ.

Stratigraphic position. Berriasian-Valanginian of Israel; bore-hole Heletz 2 (E = 115.963, N = 110.807, K.B.+92 m.); depth 1465–71 m.

Remarks. This pollen is not easy to observe optically because of the crowded sculptural elements.

Classopollis pujoli sp. nov.

Plate 58, figs. 1–4

Diagnosis. Subequatorial circular furrow present and large; trilete scar present, or trace; pseudopore diameter 3–4 μ; intrastructure pseudoreticulate; average exinal thickness 1·5 μ; equatorial thickening 2 μ; 5–6 striations; often anastomosing; band width 6–7 μ. Sculpture simple, isomorphous, isodiametric echinulate (hairy with needles); height of needles 0·6 μ, breadth 0·15 μ, abundance 24 per μ^2.

Size range. 20–6 μ (80 specimens).

Holotype. Plate 58, figs. 1–3; size 22 μ.

Stratigraphic position. Lower Portland of Charente, France; bore-hole Vignolles S_1 (X = 390.6; Y = 89.3); depth 6·80 m.

Remarks. *C. pujoli* differs from *C. hammenii* Burger in the three following characters: circular furrow is more distinct, equatorial thickening more distinct, the tracery of the intrapseudoreticulum is less distinct.

Classopollis mirabilis sp. nov.

Plate 58, figs. 5–11

Diagnosis. Subequatorial circular furrow distinctly present; trilete scar present, or trace; pseudopore diameter 4–12 μ; intrastructure punctate to pseudoreticulate; average exinal thickness 2 μ; equatorial thickening 2·5 μ; 5–6 striations; band width 5–6 μ. Sculpture simple, isomorphous, more or less isodiametric, echinulate (hairy with spines); height of spines 1–1·5 μ, breadth of bases 0·3–0·4 μ, abundance 6 per μ^2.

Size range. 24–36 μ (100 specimens).

Holotype. Plate 58, figs. 8, 10–11; size 35 μ.

Stratigraphic position. Lower Portland of Charente, France; bore-hole Vignolles S_1 (X = 390.6, Y = 89.3); depth 6·80 m.

Remarks. By light microscope observation *C. mirabilis* resembles *C. echinatus* Burger 1966; because of the absence of a clear illustration of the sculpture, it was preferable

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EXPLANATION OF PLATE 57

Light microscope figures approximately ×1000; Stereoscan figures approximately ×2000 and 10 000.

Figs. 1–5. *Classopollis aquitanus* sp. nov. 1, L.M. holotype, showing reticulate intrastructure, striations, narrow subequatorial circular furrow. 2, S.E.M. tetrad, ×1000. 3, Detail of distal polar area of central grain of tetrad showing vertical appearance of spines. 4, 5, S.E.M. holotype, showing echinulate sculpture, hairy with spines.

Figs. 6–11. *Classopollis martinottii* sp. nov. 6, L.M. paratype, showing finely punctate intrastructure, subequatorial circular furrow, equatorial thickening. 7, 8, S.E.M. views of same tetrad showing end-rounded spines of the echinulate sculpture. 9, L.M. holotype. 10, 11, S.E.M. views of the holotype. (There is a prominent scratch on the negative of fig. 7.)

EXPLANATION OF PLATE 58

Light microscope figures approximately ×1000; Stereoscan figures approximately ×2000 and 10000.

Figs. 1–4. *Classopollis pujoli* sp. nov. 1, L.M. holotype, showing intrastructure, striations, pseudopore, triangular proximal area, and exinal thickness. 2–4, S.E.M. holotype, showing echinulate sculpture, hairy with needles.

Figs. 5–11. *Classopollis mirabilis* sp. nov. 5, L.M. paratype, showing punctate to pseudoreticulate intrastructure. 9, L.M. paratype, showing striations, equatorial thickening, and subequatorial circular furrow, ×2000. 8, L.M. holotype, showing pseudopore. 10, 11, S.E.M. views of same grain showing radially combed strong spines of echinate sculpture.